Using the EPA RF3 Database to Facilitate Mandated Water Quality Reporting

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Section 305(b) of the Federal Clean Water Act requires that each State, Territory, and Interstate Commission must prepare a report every two years describing the status of water quality. This paper describes efforts to integrate the EPA's River Reach File 3 database and other existing EPA databases such as the Waterbody System in ARC/INFO format as part of a pilot project in South Carolina. Techniques for analyzing the state waters using RF3 and GIS, as well as simple menudriven interfaces to query and display water data are also addressed. These efforts are aimed at improving the State's ability to develop mandated water quality reports.

INTRODUCTION

Section 305(b) of the Federal Water Pollution Control Act, better known as the Clean Water Act, mandates that each State, Territory, and Interstate Commission must develop a program to monitor the quality of its surface and ground waters, and prepare a report every two years describing the status of water quality and water pollution control programs. The Environmental Protection Agency (EPA) is then responsible for transmitting these reports to Congress along with an analysis describing the status of water quality nationwide. In 1987, EPA developed the Waterbody System to assist States in preparing assessments of individual waters, to make preparation of tabular report summaries easier, and to get greater national consistency in the information submitted by each State. These data are used by EPA to provide national information on the quality of waters and the factors leading to impairment of those waters.

The pilot project described in this paper is a joint effort between the EPA and the state of South Carolina. Funding was provided by the EPA's Office of Wetlands, Oceans, and Watersheds, (OWOW) which is responsible for water quality data systems and the 305(b) guidance, as well as nonpoint source pollution programs and a wide variety of other programs that are best addressed through a watershed approach. The pilot was developed by EPA's Environmental Monitoring Systems Laboratory in Las Vegas, NV, which is an EPA center for GIS research and development. The pilot is designed to: index South Carolina's 305(b) waterbodies to the RF3 file, demonstrate the use of ARC/INFO as a tool for indexing waterbodies, show the value of WBS information in developing management options in a GIS, and explore the use of the Reach File in routing flows.

Waterbody System

The EPA has made available several software and data products for use in the water quality assessment process. The use of these systems by the reporting agencies helps ensure consistency, and simplifies the preparation of State reports. One of these products is the Waterbody System (WBS). The WBS is a database management suite of tools which stores and manipulates information on how well waters in the State support their designated uses such as swimming, drinking water supply, aquatic life support, etc. Guidelines are provided by EPA for determining levels of support for each designated use. The WBS also allows the generation of water quality summaries in a format suitable for mandated water quality reports.

RF3

Another important data product is the River Reach File 3 (RF3) which is a national database of 1:100,000 scale DLG hydrography data in a processed, edgematched, hydrologically networked format. Although the RF3 database was originally designed as an indexing and modeling system for the EPA IBM mainframe, recent efforts have resulted in programs which can translate RF3 into a format compatible with the Agency's standard GIS ARC/INFO. RF3 data are a "directed network" dataset meaning that all stream segments, or reaches, are ordered in a uniform direction. This is a great improvement over the original DLG data and facilitates modeling of upstream/downstream flow in a GIS.

Perhaps the most important aspect of the RF3 database is the reach numbering system used. This design identifies all "unique" stream segments with a standard numbering sequence. This numbering scheme is presently being evaluated for possible acceptance as a FIPS standard. In addition to this reach identifier, all stream features contain the reach number of upstream and downstream reaches which provides the ability to traverse the stream network using attributes alone.

The translation of RF3 into GIS format created an entirely new and much larger user community for these data. The scrutiny to which the RF3 was subjected by GIS users has resulted in the identification of several areas where RF3 data could be improved upon. One area that is being investigated is the development of stream centerlines to enable the easier traversal of open water bodies. The present systems utilizes a "stair-step" or "flip-flop" method to "walk up" both shores of an open water body. EPA is currently reviewing the status of RF3 and is planning for a major refinement which could be completed within the next year.

One of the best known and most used data/software products is the STORET system. This online water quality data storage and retrieval system provides reporting Agencies with access to the information necessary to assess water quality at given monitoring stations.

Custom STORET retrievals can be produced to identify stations that have measured contaminants in excess of State standards. These stations can then be associated with the RF3 stream network to use in network or stream allocation modeling.

WATERBODIES AND RF3

States presently aggregate reported waters into what are called waterbodies. These Waterbodies can be any combination of hydrologic features (e.g. stream segments, streams, stream networks, lakes, ponds, canals, etc). The only requirement has been that the waterbodies be defined in a consistent manner throughout the State and that the designation remain relatively stable to facilitate trend analysis. The identification of individual waterbodies is left up to the reporting agency.

South Carolina 305(b) waterbodies

The State of South Carolina designates it's 305(b) waterbodies using the U.S. Soil Conservation Service (SCS) watersheds indicated on a U. S. Geological Survey (USGS) 1:500,000 scale map of the State (Corontzes, 1992). Figure 1 displays the SCS watersheds in South Carolina along with the USGS Cataloging Units. All waters depicted on the map
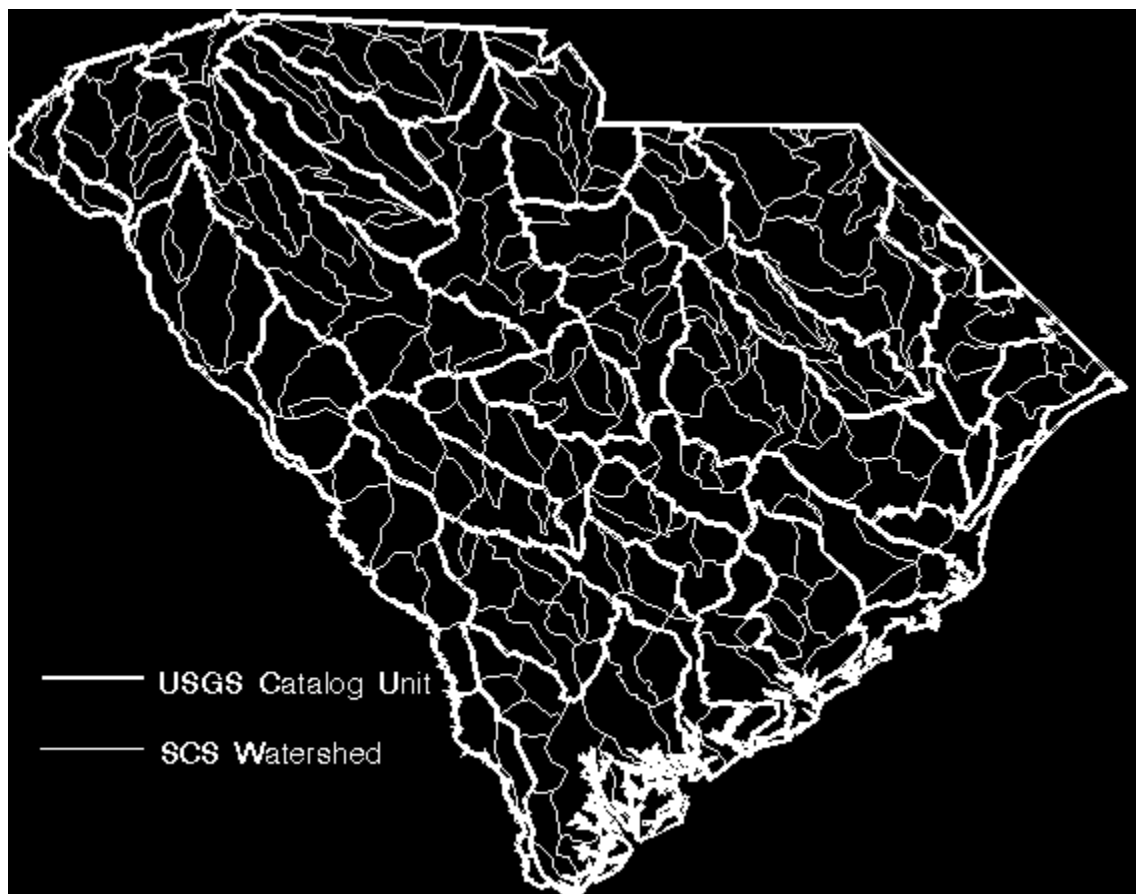
Figure 1. South Carolina USGS Catalog Units and SCS watersheds.

that fall within a given SCS watershed were designated as a unique waterbody. The code used to identify each waterbody consists of the abbreviation "SC" followed by a unique 11 digit code (8 digit USGS catalog unit code plus 3 digit SCS watershed code). A suffix indicating the type of water such as "R" for river, "L" for lake or "E" for estuarine is appended to the waterbody ID. Waterbodies were named for the dominating river, lake, or estuary in the SCS watershed. An example of waterbody SC-03050108-010R "Enoree River", defined as "the Enoree River mainstem and tributaries upstream from the confluence with Twomile Creek, excluding Beaver Dam Creek", is shown in Figure 2.
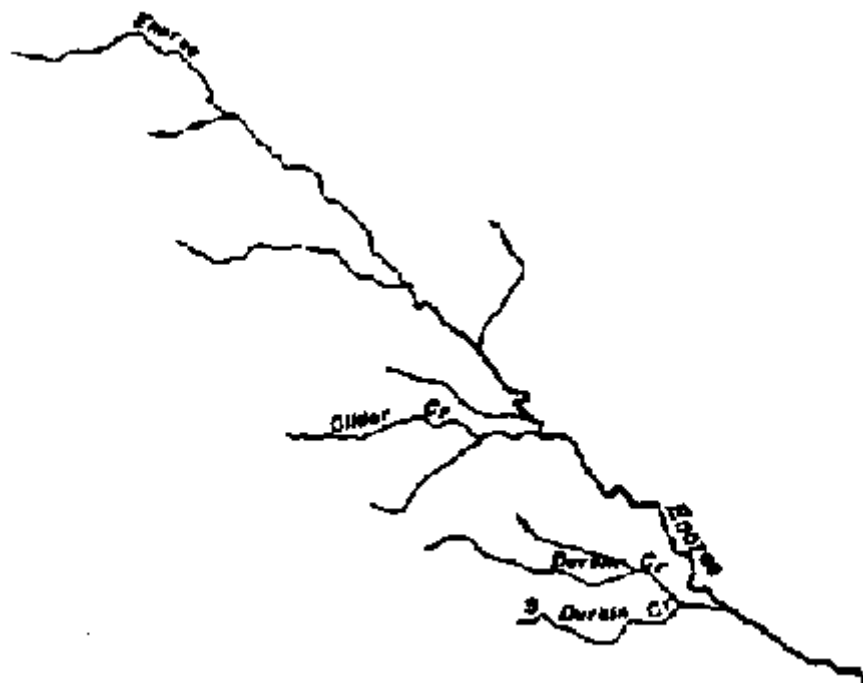
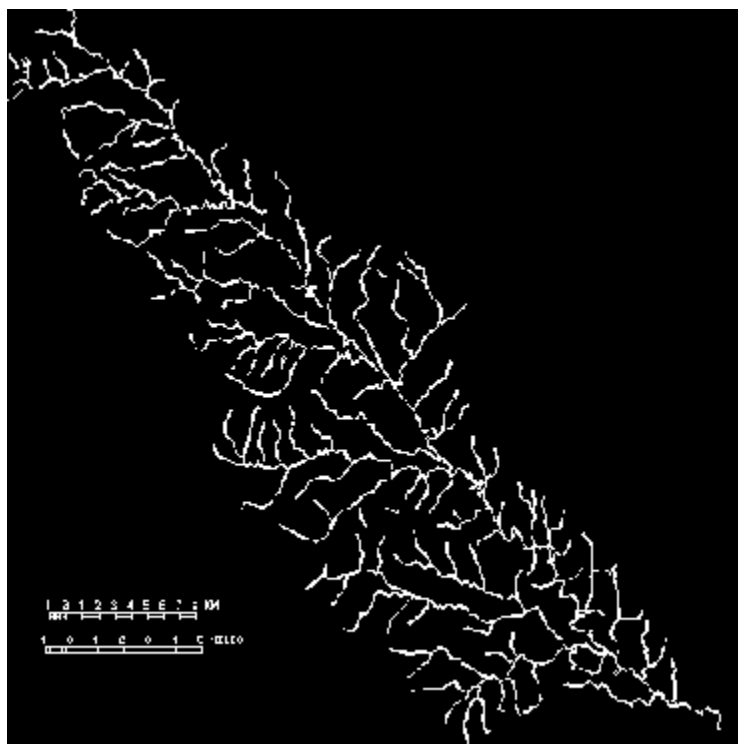**Figure 2.** 305(b) Waterbody "SC-03050108-010R" From 1:500,000 Scale Map.

Reach File 3 data

A work group made up of state and EPA representatives met in 1990 and 1991 to find ways to increase consistency between States and to improve the accuracy and coverage of State 305(b) assessments (US EPA, 1992). One of the main projects recommended by this work group was to develop a consistent methodology for estimating total State waters. The work group recommended use of the EPA's RF3 database derived from 1:100,000 scale USGS DLG data to provide the best estimate of total State waters.

One goal of this pilot project was to "index", or associate RF3 data in ARC/INFO format with South Carolina 305(b) waterbodies. In other words, to define the State's 305(b) waterbodies using RF3. For most States the use of the RF3 database will dramatically increase the total miles (length and area) of waterbodies reported in the 305(b) reports because of increased resolution over their present source(s). For example, South Carolina presently determines total State waters from the 1:500,000 scale USGS hydrologic unit map. The size reported for waterbody SC-03050108-010R (see Figure 2) using this scale base map was 106 miles. Using the RF3 database this waterbody increased in size to approximately 340 miles. Figure 3 shows waterbody SC-03050108-010R as defined using the RF3 data.

Figure 3. 305(b) Waterbody "SC-03050108-010R" From RF3 Data.

Increasing the resolution of the 305(b) reported waters is not the only advantage to using RF3 data. All RF3 reaches, or streams, have an associated reach number that is rapidly becoming an accepted method of identifying hydrologic features. Specific RF3 reach numbers associated with a given waterbody will be known and all reports can contain a reference to the specific RF3 reach numbers when defining an entire waterbody or portion thereof. Instead of solely defining waterbody SC-03050108-010R as it is defined above, the specific RF3 reach numbers involved can be cited ensuring that the geographic extent of the data are well known.

As mentioned earlier, one goal of the 305(b) reports is to define how well designated uses of waterbodies are being supported. Presently, a State may report, for example, that 15 miles of a particular waterbody are not supported for swimming. However, the State is not required to identify which 15 miles are not supported. Once the waterbody is indexed to the RF3 data, the waterbody can be broken out into specific reaches or portions of reaches thereby providing a standard reference with a known geographic position.

Defining 305(b) waterbodies using RF3 will also take advantage of an effort presently underway to index many of the EPA environmental databases to RF3. This would associate data such as permitted dischargers, or industrial facilities with RF3 reaches, which would provide an obvious link to waterbodies defined by RF3.

Indexing 305(b) waterbodies to RF3

ARC/INFO was used to perform the indexing of South Carolina Waterbodies to RF3. The actual process used was relatively simple. Overlay techniques were used to associate mid-points of individual reaches with the SCS watershed polygons in which they exist. Attributes were then concatenated to compile the waterbody I.D.s as defined above.

The result of this operation is an RF3 coverage where each reach is coded with the appropriate South Carolina 305(b) waterbody identifier. Figure 4 displays the waterbody I.D.s for USGS cataloging unit 03050108.
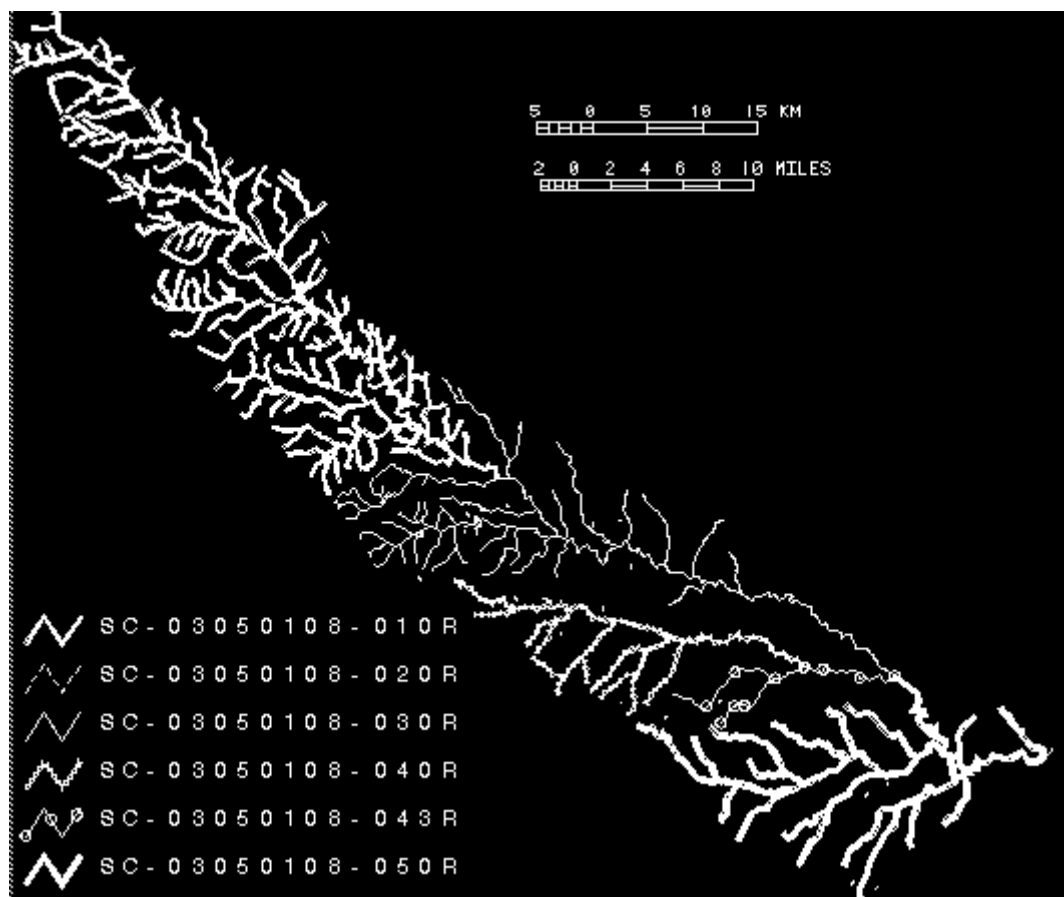
Figure 4. Waterbody IDs for Catalog Unit 03050108 - Derived from RF3 data.

Because of the high quality of the SCS watershed boundary coverage, this method worked quite well in defining South Carolina 305(b) waterbodies. Because the mid-point of each reach was overlayed with the SCS watershed polygons, the situation of reaches stretching across watershed polygon boundaries rarely resulted in wrong assignments of an SCS watershed to a reach.

The GIS process described above is not particularly robust. Instead, the importance lies in the overall strategy of providing to South Carolina a GIS database containing RF3 data coded to their 305(b) waterbodies. The State can use the RF3 reach number when referring to 305(b) support levels in their biennial reports. The State will also have the ability to use the power of GIS to query and display the hydrologic data.

Not all States define their 305(b) waterbodies in the same manner as South Carolina. Semi-automated procedures to encode RF3 reaches with waterbody IDs is a relative simple matter in South Carolina's case because of the use of SCS watershed polygons for waterbody identification. One goal of this pilot project is to develop techniques that will allow other States to use RF3 to define their waterbodies as well.

305(b) WATERBODY SYSTEM,

The WBS is a PCbased software package which maintains a database of water quality assessment information. Assessment information differs from actual raw monitoring data in that it is a subjective determination of the health of a waterbody by considering the extent of support for designated uses. The WBS program allows States to input, edit, and analyze assessment data and to generate custom or standard output reports. The WBS also includes a set of flat files and SAS programs on the EPA IBM mainframe.

WBS and GIS

As part of this Pilot Project, data from the WBS was integrated into ARC/INFO to show how GIS can be used to query and display waterbody assessment information. The WBS uses a runtime version of FoxPRO as its database manager. The FoxPRO data files containing South Carolina assessment data were converted to INFO format. Because the SCS watershed polygons are the basis for 305(b) waterbody delineation in South Carolina, the waterbody IDs in the WBS were related to the SCS polygon coverage.

A menu driven interface was created to allow easy access via ARC/INFO ARCPLOT to the 305(b) assessment data derived from the WBS. This interface displays a map of South Carolina and the SCS watershed polygons which delineate the State's 305(b) waterbodies. A query menu then appears and the user may chose the use and support categories of interest. The user then inputs the distance criteria (number of miles, or percent of total miles) to complete the query. The resulting ARCPLOT reselect might go something like this; Show all 305(b) waterbodies (SCS watersheds) where more than 25 miles of river are not supporting the swimming use.

Figure 5 shows a plot developed using the WBS data in ARC/INFO. Because the WBS maintains information on causes and sources of non-support, data on waterbodies not supporting uses due to agricultural sources could be integrated and displayed.
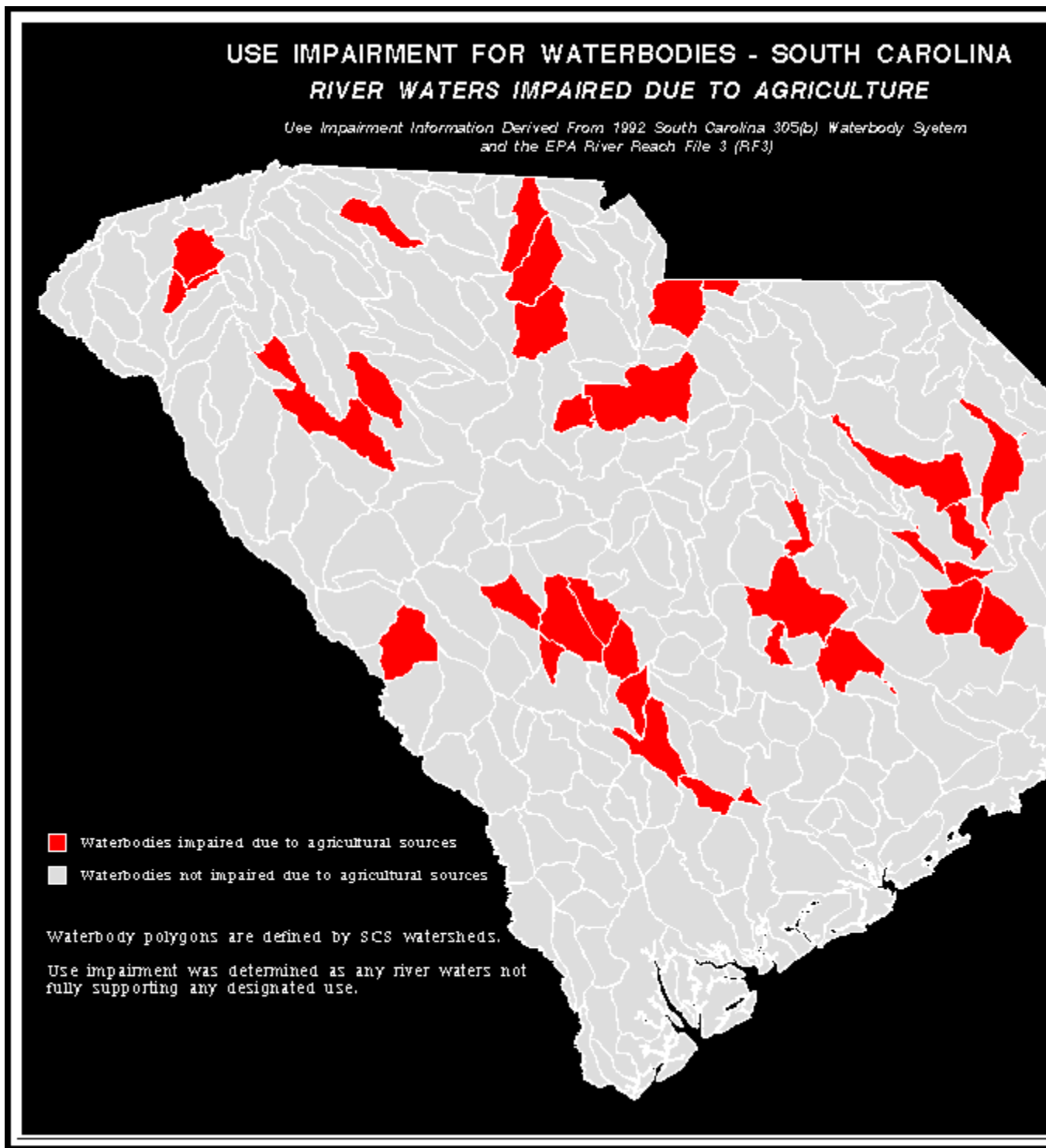
Figure 5. Plot of WBS data from ARC/INFO.

Network Modeling

Stream flow modeling using RF3 data is an important part of the South Carolina Pilot. The State plans to use ARC/INFO network modeling tools such as **TRACE UPSTREAM** to find the total length of all

reaches upstream from a station to the nearest upstream monitoring station. This would provide the "reaches of influence" for any monitoring station. Another scenario would be to find the reaches upstream from a station that has measured some contaminant, stopping at any reaches which have potential polluters located on them. Using upstream allocations such as this will be a powerful way to search for potential polluters.

Downstream modeling can also be performed with the RF3 data in GIS format. For example, the location of a chemical spill can be identified on the RF3 data and downstream modeling can be used to find the potential path of the contaminant. The closest downstream monitoring station to the spill can also be easily discovered. This would allow officials to focus their monitoring efforts on those stations directly affected by the spill.

CONCLUSION

In this time of tightening Federal and State budgets, GIS and related database management tools are proving to be cost effective alternatives in the fight for cleaner waters. As digital databases and GIS's become more readily available to those personnel charged with the development of water quality reports, we should see a steady improvement in the accuracy and quality of the information provided to decision makers.

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DISCLAIMER

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